Death and regeneration of an Amazonian mangrove forest by anthropic and natural forces

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Objectives

• General Objective.

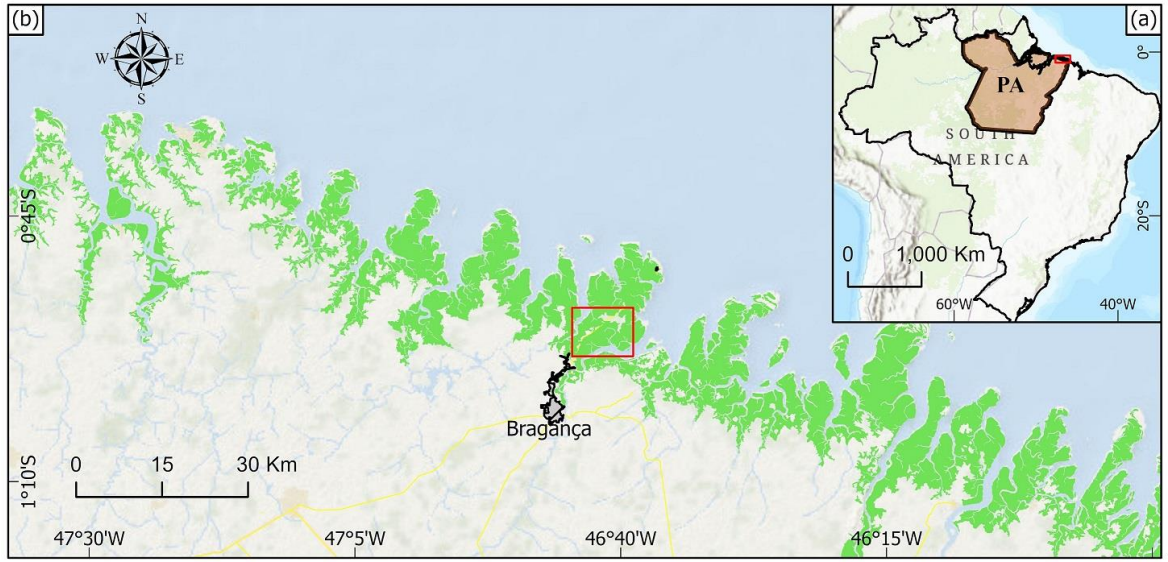
Identify anthropic and natural drivers of mangrove degradation/regeneration in the topographically higher sectors of the Bragança Peninsula during the last 35 years.

• Specific Objective.

- Quantify the degraded mangrove areas during the last 3 decades.
- Analyze the Spatial-temporal changes of the main mangrove species (*Avicennia*/*Rhizophora*) in the Bragança peninsula.
- Assess the micro-topography and vegetation height of the degraded regions of the Bragança Peninsula.

Project Location

The Bragança Peninsula is located in the state of Pará (PA), on the northeastern Brazilian Amazon (Fig. 1a), where the intertidal zone is mainly dominated by mangrove and herbaceous flats that occupy ~3090 and ~90 km2, respectively (Cohen et al., 2009). This peninsula occurs at the Amazon Macrotidal Mangrove Coast with an extensive mangrove area (Fig. 1b) and tree heights up to 25 m (Cohen et al., 2018).



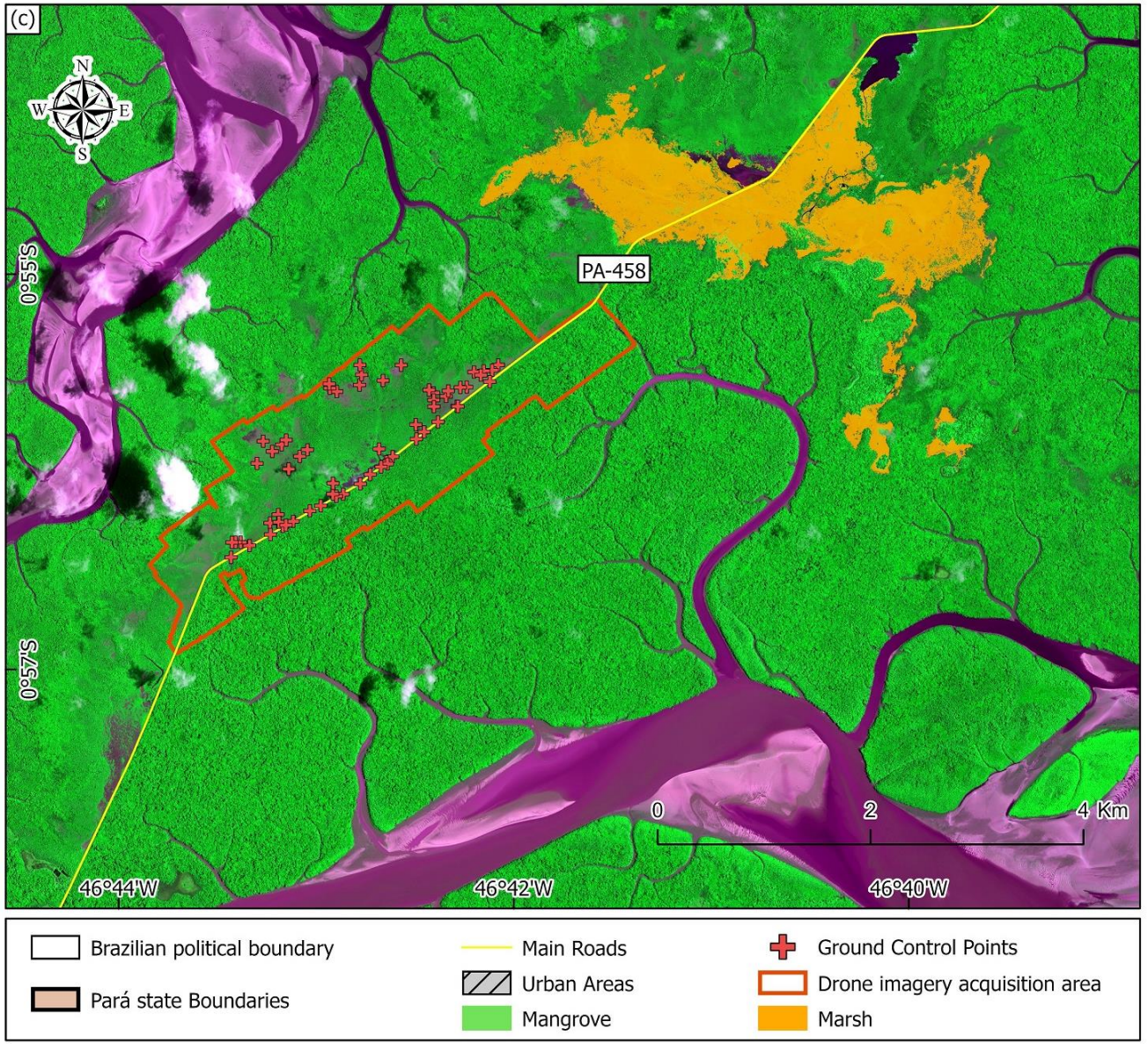


Figure 1. Study area: (a) Location of the study area in South America; (b) Mangrove coverage in the AMCC; (c) Positions of Ground Control Points (GCPs) and drone imagery acquisition in the study area.

Introduction

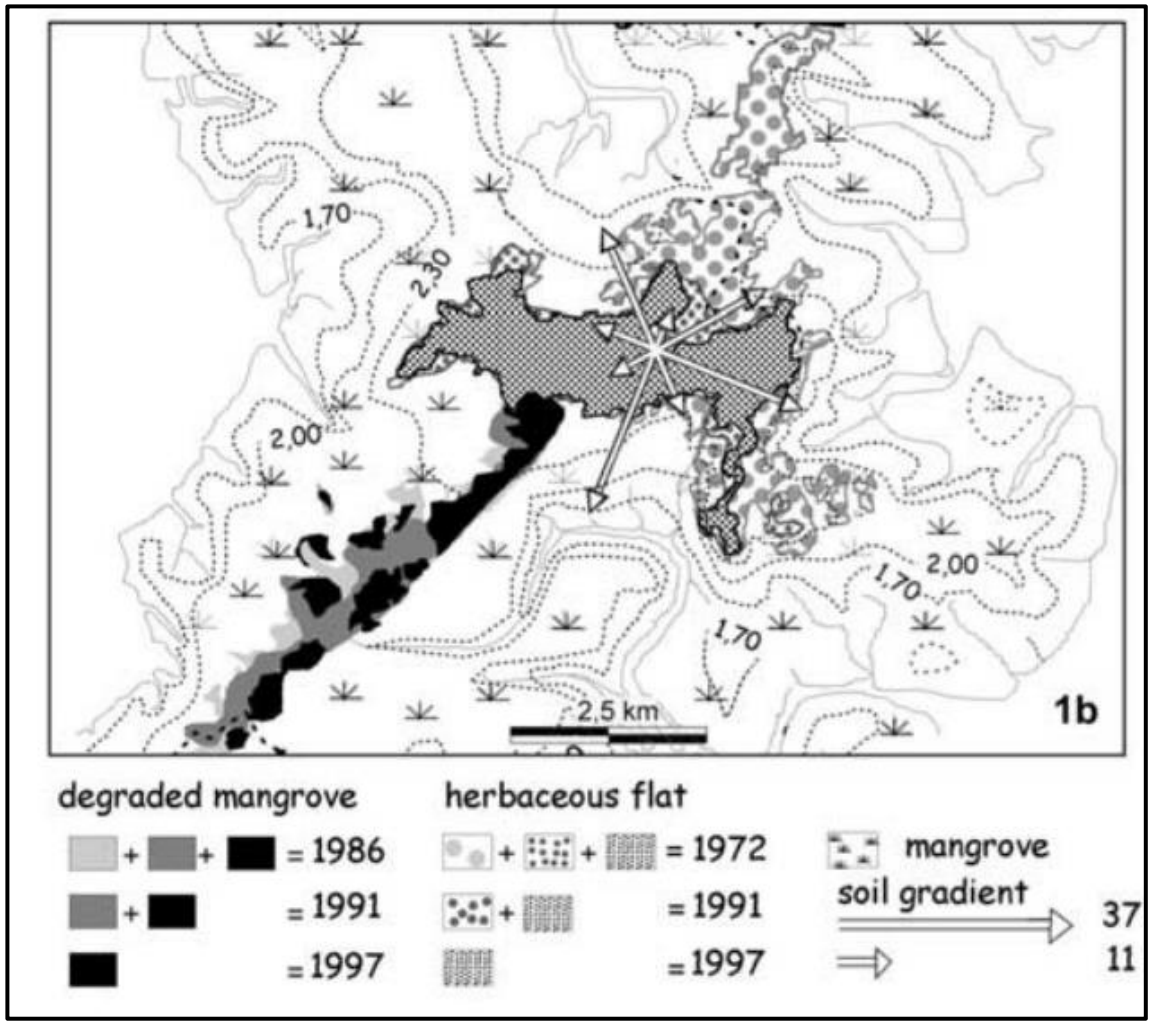
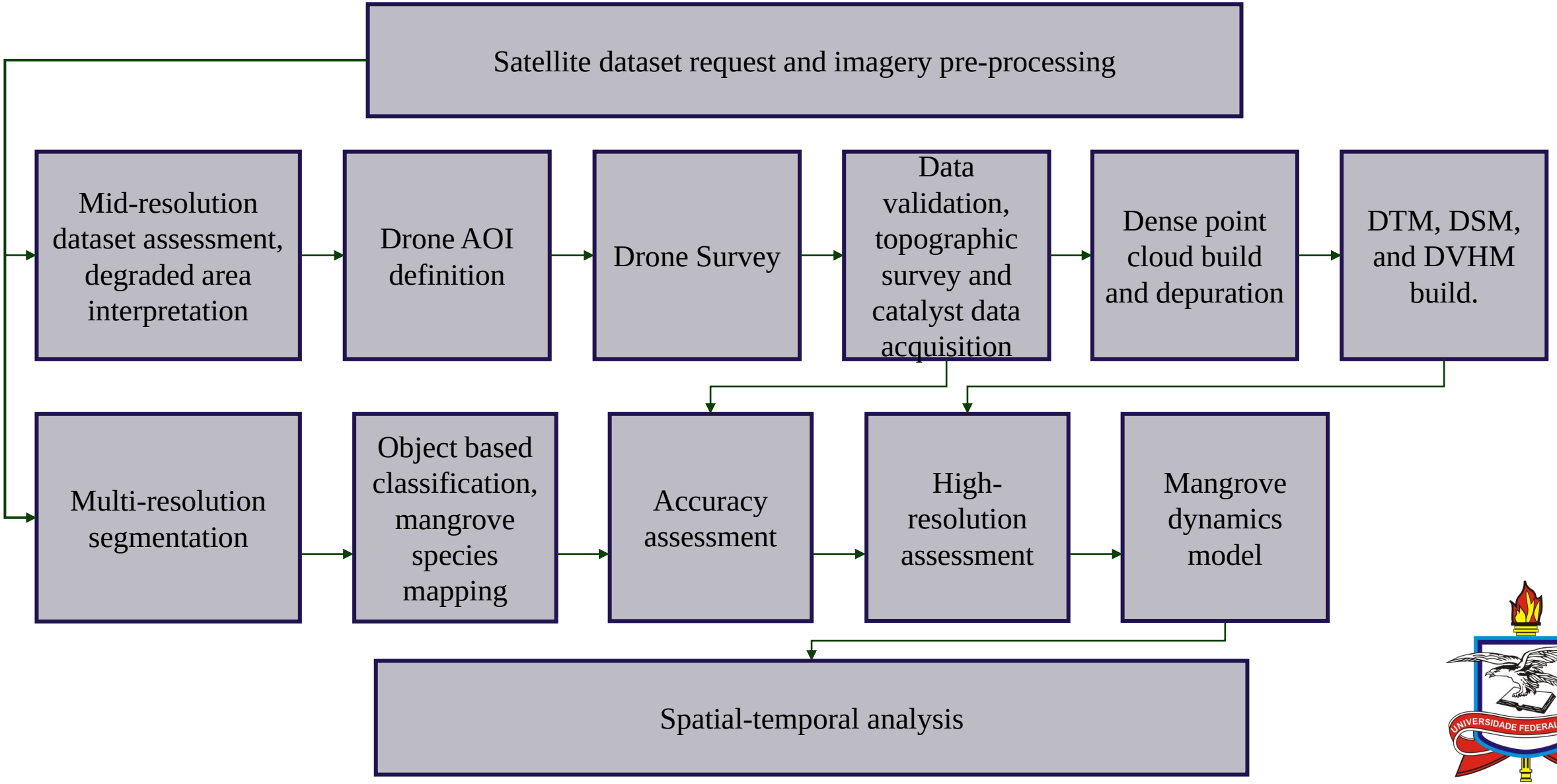


Figure 2. Progression of the mangrove front toward degraded areas and herbaceous flats (Cohen *et al.*, 2003).

Degraded mangrove areas can be found close to the center of the Bragança Peninsula, on the highest tidal flats (Fig. 2). This degradation may be related to the construction of the road Bragança-Ajuruteua during the '70s decade (Fig. 1c). This road (PA-458) was built along 26 km of dense mangrove forests

Over the last decades, several studies reported the recolonization of degraded mangrove areas, mainly by Avicennia trees on topographically elevated tidal flats (Lara et al., 2002; Souza-Filho and Paradella, 2002; Cohen and Lara, 2003; Lara and Cohen, 2006; Cohen et al., 2018).

Methods


Satellite dataset request and imagery pre-processing
Mid-resolution dataset assessment, degraded area interpretation
Drone AOI definition
Drone Survey
Data validation, topographic survey and catalyst data acquisition
Dense point cloud build and depuration
DTM, DSM, and DVHM build.
Multi-resolution segmentation
Object based classification, mangrove species mapping
Accuracy assessment
High-resolution assessment
Mangrove dynamics model
Spatial-temporal analysis

Cloud-stored data to classify mangrove species.

High-resolution multispectral data was key to assess the mangrove species dynamics in the Bragança Peninsula. To achieve this, Pléiades-1 (spatial resolution of 2 m for multispectral and 0.5 m for panchromatic) images were downloaded through Sentinel-Hub's Third Party Import Data API. This data was fused by the Gram–Schmidt spectral sharpening method to produce 0.5 m pan-sharpened imagery.

To perform the mangrove species separation, we took advantage of the difference in the spectral response that the two species have between the wavelengths of 500 and 600 nm (Rebelo-mochel and Ponzoni, 2007). The wavelength interval in the Pleiades-1 sensor corresponds to the green band. This difference translates into higher reflectance peaks in the *Avicennia* trees. The classification was carried out through a Geographic Object-Based Image Analysis (GEOBIA). Classification results area summarized in Figure 3.

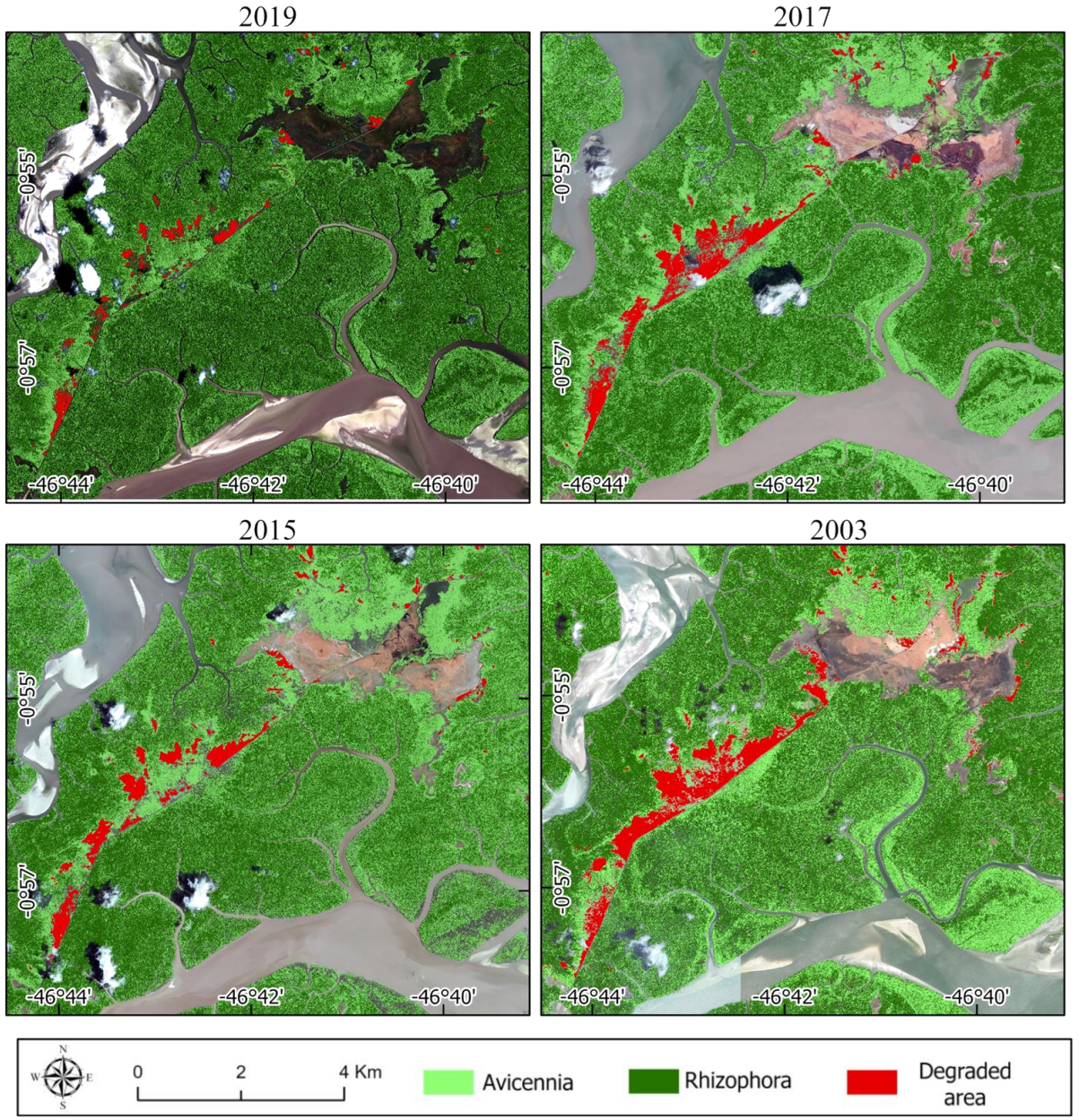


Figure 3. Multitemporal changes of the mangrove cover in the Bragança Peninsula using high-resolution images from 2003, 2015, 2017, and 2019.

Cloud-stored data to classify mangrove species.

The Pléiades-1 data allowed us to determine that mangrove regeneration occurs not only by *Avicennia* (Specie with high tolerance to porewater salinity) but also by *Rhizophora* (Fig. 4). Leading us to conclude that the porewater salinity of the tidal flats is decreasing. This porewater salinity decrease may be attributed to a higher tidal inundation frequency.

The global average sea-level rise trend during the last decades, combined with the soft topography of the tidal flat in the Bragança Peninsula, seems to stabilize the hydrological dynamics affected by the PA-458 road construction. Thus, sea-level rise may have triggered the mangrove regeneration by colonizing Avicennia and Rhizophora mangrove trees from the lower to higher flats

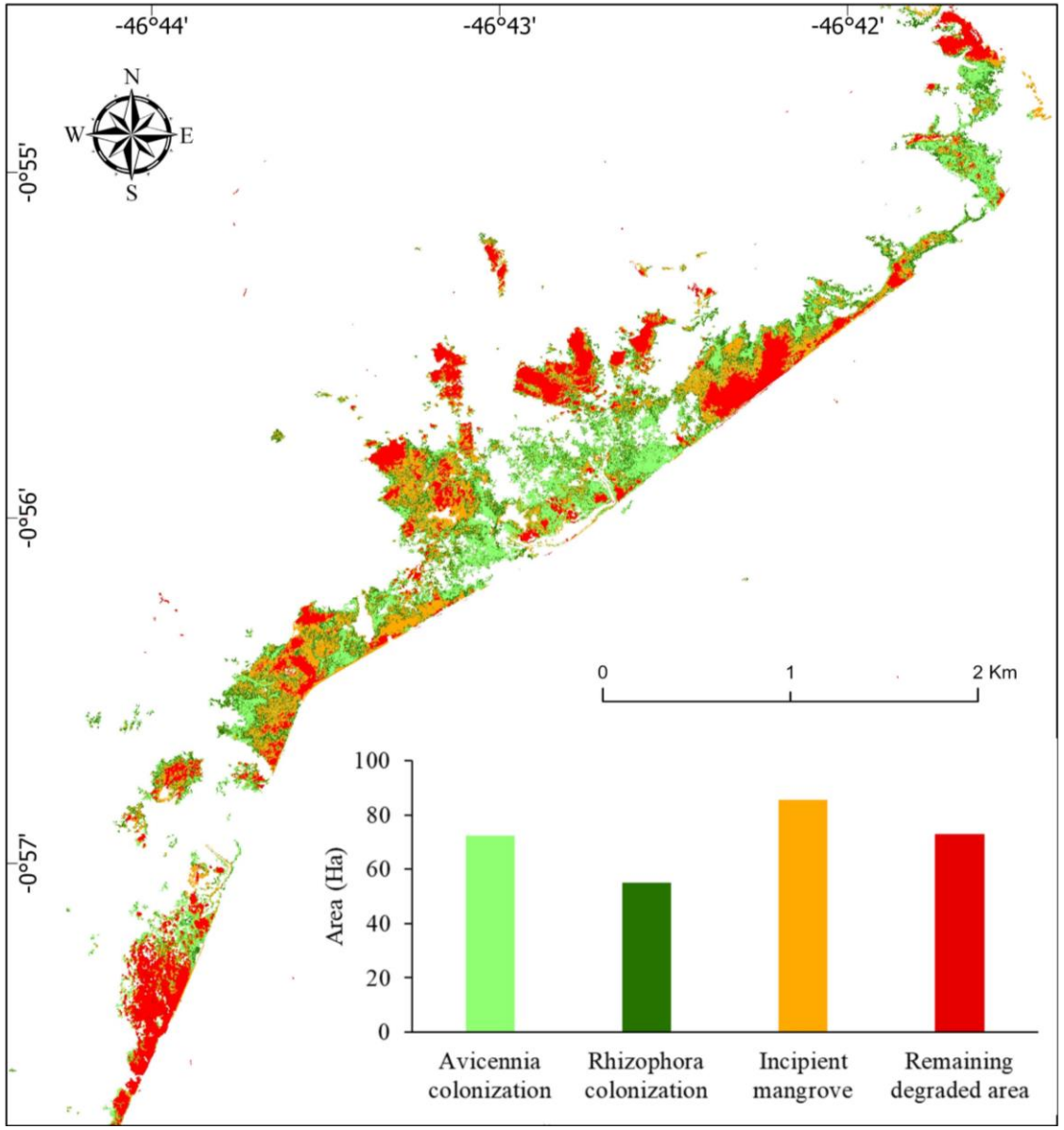


Figure 4. Changes in the degraded area between 2003 and 2019 using high-resolution images.

Highlights

- Combining planialtimetric data with high and mid-spatial-resolution datasets, indicated that the construction of road PA-458 in 1973 degraded at least 430 ha of mangroves in the Bragança Peninsula, by tidal channel interruptions previously connected with the Caeté estuary, killing mangrove trees mainly on the NW side of this road. Though road construction leads to social benefits as mobility and tourism increase, mangrove degradation represent a loss of benefits like coastal sequestration and storage of carbon, conservation of biological diversity, and coastal protection against the effects of storms and inundation by sea-level rise.

- The present study sets a precedent to minimize the impacts on mangroves by anthropic constructions. In this study, the PA-458 road should have been projected to cross mangrove areas on the highest tidal flats and skirting the channel headwaters to avoid interruption of regular tidal flow along these channels.

- The relative sea-level rise during the last decades caused a long-term mangrove recolonization from low to higher tidal flats. It is an example of how local environmental changes are evidences of climate change cosequences.

Project current status

- The Master's degree dissertation derived from this project can be found published in the following link:

http://repositorio.ufpa.br/jspui/bitstream/2011/14422/1/Dissertacao_AnaliseEspacoTemporal.pdf.

- A scientific paper has been derived from the project and published in the remote sensing journal:

https://www.mdpi.com/2072-4292/14/24/6197

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